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Population study for monitoring the status of rarity of three Aconite species in Garhwal Himalaya

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Abstract: Alpine and subalpine regions of Garhwal Himalaya were surveyed quantitatively for the population study to determine the status of three aconites viz., *Aconitum balfourii, A. heterophyllum* and *A. violaceum*. Population data of these three aconites revealed that they are restricted to specific pockets and had very low population density. Illegal and over exploitation of these species pose threat to their existence. However, to assign the categories of threats population status of aconites has not been quantified so far. Present study summarizes the population dynamics of identified aconite species in Garhwal Himalaya. Observations reveal that on the basis of population density and degree of constancy (occurrence) used to assign threat categories, all the three *Aconitum* species are endangered. Furthermore, these observations would be helpful in monitoring the threat categories in future on the basis of population reduction.

Resumen: Las regiones alpina y subalpina de Garhwal Himalaya fueron inspeccionadas de manera cuantitativa para este estudio poblacional con el fin de determinar el estado de tres acónitos: *Aconitum balfourii, A. heterophyllum* y *A. violaceum*. Los datos poblacionales de estos tres acónitos revelaron que están restringidos a puntos específicos y que tienen una densidad poblacional muy baja. La explotación ilegal y desmedida de estas especies representa una amenaza para su existencia. Sin embargo, para asignar las categorías de amenaza, el estado poblacional de los acónitos no ha sido cuantificado todavía. El presente estudio resume la dinámica poblacional de las especies de acónitos identificadas en Garhwal Himalaya. Las observaciones revelan que con base en la densidad poblacional y el grado de constancia (presencia) utilizado para asignar las categorías de amenaza, las tres especies de *Aconitum* están en peligro. Adicionalmente, estas observaciones serían útiles en el monitoreo futuro de las categorías de amenaza sobre la base de la disminución poblacional.

Resumo: Para determinar o status de três aconites, a saber, *Aconitum balfourii*, *A. heterophyllum* e *A. violaceum* foi efectuada uma inventariação quantitativa da população nas regiões alpinas e sub-alpinas no Himalaia Garhwal. Os dados de população destas três aconites revelaram que elas se encontravam restringidas a bolsas específicas e apresentavam ums densidade populacional muito baixa. A sobre-exploração ilegal destas espécies ameaça a sua existência. Contudo, para inscrever as aconites com o status de espécie ameaçada não foi realizada até agora um trabalho de quantificação. O estudo apresentado sumaria a dinâmica da população das espécies de aconites identificadas no Himalaia Garhwal. As observações revelam que na base da densidade populacional e grau de consistência (ocorrência) usada para incluir a espécie na categoria de espécie ameaçada, as três *Aconitum* estão em perigo. Além disso, estas observações serão úteis na monitorização de categorias em risco tomando por base a redução de população.

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Key words: Aconite, alpine, degree of constancy, subalpine.

Introduction

Aconites are widely recognized for their medicinal importance. In the Himalaya, *Aconitum balfourii* Stapf., *A. heterophyllum* Wall. (Atis), and *A. violaceum* Jacquem. (Patis, Dudhiya atis) are well known medicinal plants used in Indian System of Medicine (ISM). Due to continuous exploitation and habitat destruction, these species are becoming rare. Out of 113 taxa, identified as threatened in Indian Himalaya, only a few species, for example, *Podophyllum hexandrum* have been studied for population dynamics in Western Himalaya (Airi *et al.* 1997). *A. balfourii* and *A. heterophyllum* are endangered in status and *A. violaceum* is assessed as vulnerable in Himalayan region and steady decline in their population size is reported (CAMP Report 1998). The rarity of these species can be evaluated on the basis of their occurrence in nature. Since these are endemic to small geographic area (Jain & Rao 1983) and have specific localities and pockets, according to Red List Categories published by IUCN (1993), species with small geographic area, narrow habitat specificity and commonly sparse and geographically restricted to special habitat are considered as rare.

Ecosystems and biomes are getting established as the webs – nuts and bolts of them are being dismantled by man. Due to man induced changes in form of over and illegal exploitation of plants in areas of high conservation values, centers of endemism and species diversity, the original habitat is fragmented into isolated patches leading to fragmentation of species population as in case of alpines of the Himalaya (Tandon 1998). The rate of extinction is faster in such smaller group than in bigger habitat as ecological niches available for the survival are proportionately reduced. Investigations were made on taxonomy and ecology of alpine communities of Garhwal by several workers including Naithani (1983, 1984), Semwal *et al.* (1981), Ram & Arya (1991), Negi *et al.* (1992), Nautiyal *et al.* (1997, 2000) and Gaur (1999). However, confusion on distribution and lack of data on quantum availability of individual species still persists. A detailed survey of these aconites was undertaken for quantitative analysis throughout the Garhwal region. These observations will (i) furnish a system that can be applied consistently, (ii) facilitate comparisons across widely different taxa and, (iii) help in better understanding of clarification of threatened species. Also, it will provide essentially simple and assimilated data on current status of species population which can be used for assigning the categories of threat as suggested under IUCN Red List Categories (1993).

Materials and methods

Subalpine and alpine regions were surveyed during the active growth season (May-November 1998) for the collection of three species of aconite in Garhwal Himalaya. The area surveyed include: Madhyamaheshwar (MD, 3000 – 4400 m), Kedarnath (KN, 3200 – 3800 m) and Tungnath (TN, 3450 – 3750 m) in Rudraprayag district; Hemkund (HK, 3500 – 4400 m) and Valley of Flowers (VF, 3000 – 3500 m) in Chamoli; Panwali Kantha and adjacent areas (PK, 3000 – 4800 m) in Tehri; and Hari Ki Dun (HKD, 3000 – 3500 m) and Dayara (D, 3000 – 3500 m) in Uttarkashi (Fig. 1).

Alpine and subalpine regions in Himalaya are characterized by the cold climate with heavy snow fall in winters, hail storm, dense frost, drought, low CO_2 and O_2 concentration, high solar radiation and humid summer with high wind velocity. Rainfall is typical monsoonic type and daily minimum temperature reaches near freezing point throughout the season. Diverse topography and altitudes influence the vegetational pattern in the region.

Natural pockets of aconites were analyzed for quantitative study. Four plots (20 x 20 m) were identified in each location. Ten quadrats (50 x 50 cm) were laid randomly in each plot following Kershaw (1973). Quadrat data were used to determine percent frequency, abundance, density and total basal cover of each species present in community by using the methods of Misra (1968). Importance Value Index (IVI) of each species was calculated for the determination of dominance and ecological

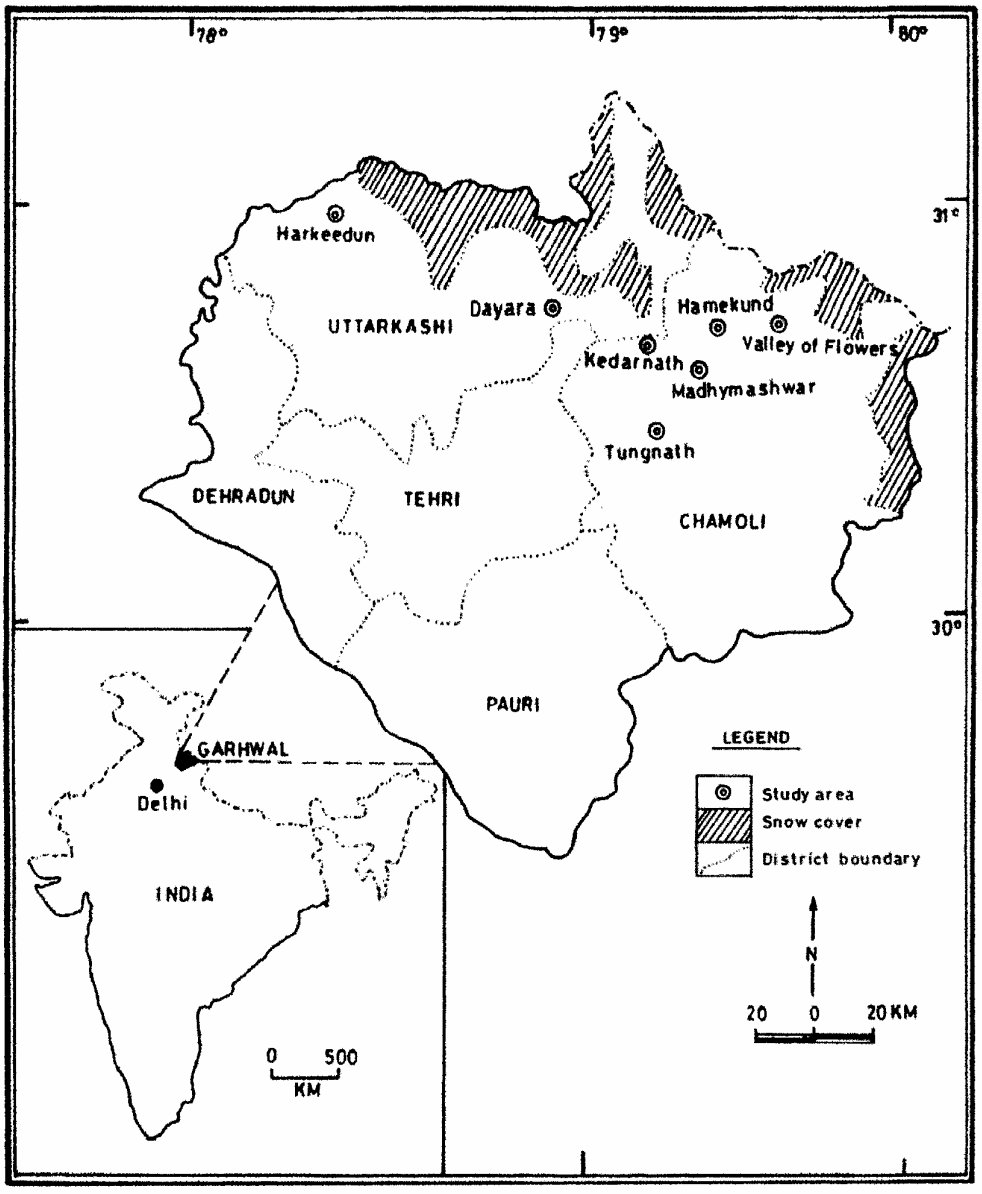

Fig. 1. Location map of the study area.

success of a species (Curtis & McIntosh 1950). Further, total numbers of pockets were identified in which species occurred in each area to determine percent presence of species. The degree of presence of a species was determined following Braun-Blanquet (1951). However, in present study we used the term "degree of constancy" instead of degree of presence as data of species presence were derived from samples taken from plots of known and limited area. So, frequency values were used to determine degree of constancy. Species having frequency between 1-20 was considered as rare, 21-40 seldom, 41-60 often, 61-80 mostly and between 81-100 as constantly present. Fidelity of species was calculated (Willard 1979). Similarly, Frequency x Presence index (P x F) was calculated to determine their presence at particular altitude and species importance for the area under study (Curtis 1959).

Results and discussion

Performance details, at different altitudes, of identified taxa (i.e. *Aconitum balfourii, A. heterophyllum* and *A. violaceum*) are presented (Tables 1-3). *A. balfourii* showed the highest frequency (70%) and density (3.71 plants m^{-2}) at 3200 m (near timberline) in Dayara. As such, the three sites at Dayara exhibited higher density compared to other sites in the region (Table 1). *A. heterophyllum* showed maximum frequency (70%) and density (2.57 plants m^{-2}) at 3500 m asl in Tungnath. The lowest density for this species was recorded in HKD (1.0 plant m^{-2}) despite contributing maximum density (1.63%) to total community density at this site. Frequency of *A. violaceum* was maximum 80% at 4700 m asl in PK where the plant grows on pasture habitat and minimum (60%) at 4100 & 4300 m asl in HK. Among three aconites, *A. violaceum* showed higher density and percent contribution to total community density perhaps due to inaccessibility of habitats or exploitation. Total basal cover of *A. balfourii* was highest in Dayara (0.320 – 0.369 cm^2 m^{-2}) and decreased simultaneously in pasture land (MD) with increasing community density. Percent value of TBC of *A. balfourii* was highest in TN (16.52) and in MD (12.35%). The value of TBC was highest (0.398 cm^2 m^{-2}) for *A. heterophyllum* in TN while lowest TBC was recorded in other pockets in TN. Percent con-

Table 1. Population analysis of *Aconitum balfourii* communities at different locations in Garhwal Himalaya.

Site*	Altitude (m)	%F	Density (plants m^{-2})	TBC (cm^2m^{-2})	IVI	% Contribution to community TBC	% Contribution to community density	Degree of constancy
D	3000	60	2.4	0.343	13.36	7.81	11.82	often
	3200	70	3.71	0.322	12.66	4.38	11.87	mostly
	3300	50	3.50	0.369	18.36	6.84	13.87	often
HKD	3100	50	0.8	0.169	18.88	2.857	2.14	often
KN	3450	40	1.4	0.322	14.62	7.33	4.77	seldom
	3650	50	1.5	0.307	18.05	4.83	5.52	often
MD	4300	40	1.6	0.291	5.94	2.35	0.87	seldom
PK	3300	50	1.5	0.365	16.19	8.26	5.85	often
	3400	40	1.6	0.346	15.12	5.26	6.57	seldom
TN	3500	60	1.3	0.263	22.66	4.57	6.57	often
	3600	60	1.4	0.343	32.77	9.42	5.69	often
VF	3000	30	1.8	0.292	16.33	5.48	4.06	seldom

*D – Dayara; HKD – Hari Ki Dun; KN – Kedarnath; MD – Madhyamaheshwar; PK – Panwalikantha; TN – Tungnath; VF – The Valley of Flowers

Table 2. Population analysis of *Aconitum heterophyllum* communities at different locations in Garhwal Himalaya.

Site*	Altitude (m)	%F	Density (plants m^{-2})	TBC (cm^2m^{-2})	IVI	% Contribution to community TBC	% Contribution to community density	Degree of constancy
HKD	3450	60	1.0	0.143	14.91	2.947	1.67	often
KN	3450	60	1.8	0.298	11.23	3.474	1.15	often
	3550	60	1.9	0.293	11.10	3.367	1.19	often
MD	3400	50	1.2	0.187	3.93	0.579	0.487	often
	3500	70	1.2	0.194	8.54	2.076	0.547	mostly
	4200	50	1.3	0.204	5.76	1.650	0.717	often
PK	3400	60	1.5	0.223	9.21	2.60	0.667	often
	3550	50	1.6	0.223	8.28	2.95	0.687	often
TN	3500	70	2.57	0.398	12.38	3.917	0.858	mostly
	3600	40	1.00	0.159	7.84	2.017	0.387	seldom
	3600	30	1.38	0.220	12.78	4.737	0.577	seldom

*Same as in Table 1

tribution to community basal cover of *A. heterophyllum* ranged between 0.579 (MD) to 4.737 (TN). Similarly, *A. violaceum* had basal cover between 0.009 (KN) to 0.024 (PK) and contributed little to community basal cover in all sites.

Considering that the IVI provides an excellent marker for determining the status of distribution and availability across varying environmental and biotic conditions (Negi *et al.* 1992; Ram & Arya 1991), value of three aconite species were compared. Values varied from one population to other. This difference can be attributed to varying species number, topography, biotic and abiotic interferences in community (Nautiyal 1996). *A. balfourii* had minimum IVI at higher elevation (5.94 MD) in steep pastures while it was recorded maximum in TN (32.77) where timberline (Krumholtz zone) reaches upto 3700 m altitude. *A. heterophyllum* showed maximum IVI value of 14.91 in HKD and lowest value of 3.93 in MD. Similarly, *A. violaceum* had maximum IVI value in HK (39.40) and lowest in KN (10.37).

Degree of constancy (measure of omnipresence of a species in a given community) for *A. balfourii* was measured as "often" in most of sites and "seldom" in one or two pockets having poor occurrence. *A. heterophyllum* shows mixed response for "often" and "mostly". However, *A. violaceum* was "mostly" in presence except one (Table 3). Measurement of ecological amplitude of species under a specific set of conditions or measure of indicator value of species can be determined in terms of fidelity (Willard 1979). According to degree of fidelity (i.e., degree of exclusiveness towards a particular community) as suggested by Braun-Blanquet (1932) these aconites can be considered as exclusive or selective species, which are confined to one (rarely in more) communities (Table 4). Percent presence of *A. balfourii* and *A. heterophyllum* was recorded very low which might be due to their specific habitat requirement and or due to uninterrupted removal of plants/bulbs for the medicinal uses. However, P x F index was recorded high for all the species (Table 4), suggesting higher adaptability against biotic factors and topographic gradients. These observations indicated that though they are of prime importance for the survival in these regions, highly adapted in specific pockets but, had least occurrence and low density only because of continuous exploitation and uprooting by man and now these species are restricted to specific localities and pockets in small number.

Low seed viability, obstruction of reproductive phases by juvenile phases (long vegetative growth period), fronts and early snow fall coupled with biotic interference prevents seed maturation and reduced plant population in most of alpine vegetation (Nautiyal *et al.* 1997, 2001; Pandey *et al.* 2000). Hence they emerge through underground perennating organs (tubers). Tubers of aconites in Garhwal are exploited for their medicinal uses since time immemorial, which caused severe threats to their existence. However, the rate of threat or rarity is not determined quantitatively. On the basis of above interpretations, it is clear that population of *A. balfourii* and *A. heterophyllum* is severely fragmented i.e. no subpopulations/pockets estimated to contain more than 250 mature individuals (on the basis of density) and all the individuals of species are in specific pockets and occur often or seldom. These observations reveal that *Aconitum* species are endangered as assessed by IUCN Red List Categories (1993) on the basis of population estimation. Consequently, quantitative data on population of these species would be helpful in the determination of their

Table 3. Population analysis of *Aconitum violaceum* communities at different locations in Garhwal Himalaya.

Site*	Altitude (m)	%F	Density (plants m^{-2})	TBC (cm^2m^{-2})	IVI	% Contribution to community TBC	% Contribution to community Density	Degree of constancy
HK	4100	60	6.7	0.014	39.40	0.42	14.77	often
	4300	60	6.7	0.013	35.40	0.54	17.40	often
KN	3700	70	4.5	0.010	15.60	0.15	5.27	mostly
	3800	80	2.8	0.009	10.37	0.14	3.34	mostly
PK	4300	70	7.8	0.019	20.12	0.40	7.16	mostly
	4400	80	9.0	0.024	22.15	0.52	8.25	mostly
	4700	80	9.5	0.023	20.95	0.41	8.88	mostly

*Same as in Table 1; HK - Hemkund

Table 4. Percent presence and P x F index of three Aconites in different alpine regions of Garhwal Himalaya.

Site*/ Location	Altitude (m)	*A. balfourii*		*A. heterophyllum*		*A. violaceum*	
		% Presence	P x F	% Presence	P x F	% Presence	P x F
Dayara	3000	40	2400	–	–	–	–
	3200	20	1400	–	–	–	–
	3300	20	1000	–	–	–	–
HK	4100	–	–	–	–	40	2400
	4300	–	–	–	–	60	3600
HKD	3100	20	1000	–	–	–	–
	3450	–	–	40	2400	–	–
KN	3450	20	800	40	2400	–	–
	3550	–	–	40	2400	–	–
	3650	20	1000	–	–	–	–
	3700	–	–	–	–	40	3000
	3800	–	–	–	–	40	3200
MD	3400	–	–	40	2000	–	–
	3500	–	–	40	2800	–	–
	4300	20	800	60	3000	–	–
PK	3300	40	2000	–	–	–	–
	3400	20	800	20	1200	–	–
	3500	–	–	40	2000	–	–
	4300	–	–	–	–	60	4200
	4400	–	–	–	–	60	4800
	4700	–	–	–	–	80	6400
TN	3500	20	1200	60	4200	–	–
	3600	20	1200	60	2400	–	–
	3600	–	–	60	1800	–	–
VF	3000	40	1200	–	–	–	–

*Same as in Tables 1 & 3

status by examining occurrence, population density of species, total basal area and their dominance (IVI) in alpine communities. These observations would also be helpful in determining the status of other species and can be applied for conservation strategies.

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